Understanding geovisualization users and their requirements – a user-centred approach

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1. Introduction

Despite offering promising techniques and interactions, uptake of geovisualization applications has been slow and problems have been reported by researchers when users have attempted to engage with the software. We offer a small scale, detailed case study (Gerring, 2004) in the design, development and evaluation of tools to support geovisualization through user-centred approaches. User-centred techniques are employed and evaluated in the context of geovisualization to guide those involved in the use and development of tools that support this process. We determine which aspects may usefully inform designers in addressing the particular difficulties experienced in building usable geovisualization software, and report upon our experiences in understanding users and their tasks, and in establishing requirements.

Slocum et al. (2001) consider that "evidence for the successful adoption of geovisualisation techniques has been limited"; Andrienko and Andrienko (2006) state that "the use of visualization tools by people different from the tool designers seems to be quite limited", and Fuhrmann et al. (2005) ask if "novel tool designs are actually usable and useful for knowledge discovery and decision making?" Some researchers have employed user-centred techniques for geovisualization (Slocum et al., 2003; Robinson et al., 2005) with varying degrees of success. Andrienko et al. (2006) have documented broader user understanding difficulties. Generally visualization researchers appear to engage only seldomly with users - in an analysis of 65 papers describing new visualizations, Ellis and Dix (2006) discovered fewer than 20% reported employing user evaluations. With this background, it is timely to consider what the methods of human-computer interaction (HCI) can contribute, their limitations, and how they might be modified for the particular characteristics of geovisualization (Dykes, 2005).

Those who argue that geovisualization is beneficial consider it a *process.* This process involves ideation and knowledge discovery and is supported by interactive software tools (MacEachren and Kraak, 2001). A *user-centred* approach would consider this process as beginning well before software design and involving fully understanding users, their needs and their requirements to meet particular tasks, as well as software design, development, use and evaluation.

2. Approach

Our approach to the deployment of geovisualization is fully situated in an organisational context rather than being predominantly technology driven. User-centred techniques are employed at the outset to understand users and their requirements in relation to a proposed application of geovisualization for the analysis of spatial data and we evaluate the appropriateness of these methods. This is achieved by identifying candidate methods from the HCI literature at each stage of the process, selecting the most appropriate methods for specific circumstances, reflecting upon their effectiveness and any limitations and making modifications to address these. Our provisional findings suggest that some of these methods are appropriate, but that some specific enhancements are required.

The study was conducted among a team of research officers working in crime and disorder reduction who operate within a wider group of analysts in Leicestershire County Council (LCC). Team members represent potential users likely to benefit from and adopt geovisualization as they undertake exploratory work with multivariate spatio-temporal data, use graphics for communication and analysis, have experience of a geovisualization prototype (Attilakou, 2005) and consider that geovisualization may help them with their work.

In order to understand these potential users, a two-week data collection exercise took place. Preece, Rogers and Sharp (2002) describe four methods for finding out about users and their tasks: ethnography, Coherence, contextual inquiry and participatory design, each of which has strengths and weaknesses. In practice, a combination of ethnography and contextual inquiry (Beyer and Holtzblatt, 1998) was used, combining ethnography's depth and the systematic and well-structured approach offered by contextual inquiry. Reference material (publications, metadata on datasets) was collected and open-ended interviews conducted (structured with the contextual inquiry methodology in mind), recorded in audio and transcribed. The lengthy transcription process gave a good insight into the major aspects of the LCC research officers' work and allowed key themes to be identified. Email communications between the LCC research officers and us relating to supplementary enquiries or questions of clarification constituted another data source. The transcripts (with our own words edited out) and supplementary emails formed a corpus of written material suitable for Content Analysis (Krippendorff, 2003) and were formally evaluated using concordance software (Hüning, 2003), calculating word frequencies and showing keywords-in-context (KWIC) (Luhn, 1960). The results assisted the categorisation process and illuminated relative priorities among items raised by users. The robustness of our understanding of the research officers' work was confirmed when we iterated the key themes identified back to the primary research officer for comment.

Having achieved an understanding of potential users, requirements can be established. A number of different user-centred methods exist for this process (Nikula and Sajaniemi, 2002). Robertson (2001) suggests techniques to 'trawl' for requirements and a template for guidance in the form of the Volere system (Robertson and Robertson, 2006). Individual team members were interviewed for an hour each using this template. The material was audio recorded, transcribed and analysed in a similar way to the earlier material.

Once requirements are established, developers need task descriptions. A range of formal (hierarchical task analysis, GOMS) and somewhat overlapping informal methods (scenarios, use cases, essential use cases) exist, and for a small scale development, informal tools are more suitable (Preece, Rogers and Sharp, 2002). An appropriate approach is to create a "scenario" based on a part of the work of LCC research officers. Scenarios are 'stories about people and their activities…[that] support reasoning about situations of use' (Carroll, 2002).

Task descriptions lead to conceptual designs and on to prototyping. Prototypes of the application will be iterated with the potential users, firstly using paper prototyping (Snyder, 2005), where we will explore the extent to which the technique can provide useful insights for an interactive application, before committing to writing code for high level prototypes.

Figure 1 shows how various human-computer interaction (HCI) techniques mediate between users and developers, compared to the technology driven model that has been used in much geovisualization development.

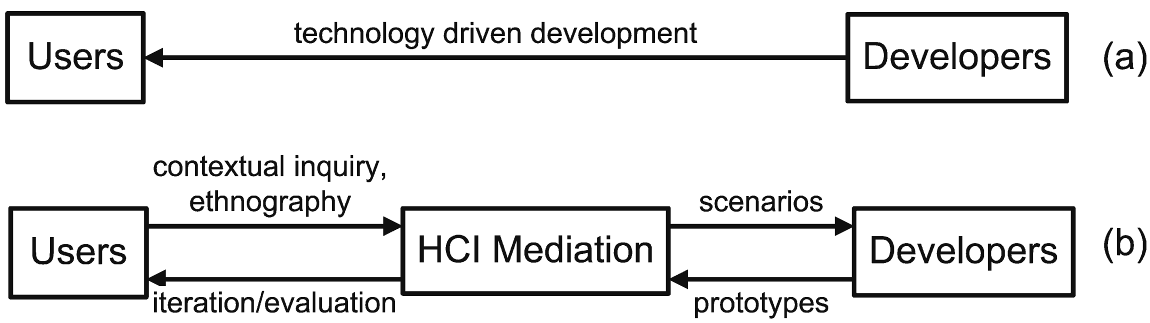

Figure 1: Two models of user interaction as part of developing geo-visualization applications. (a) technology driven, (b) HCI techniques mediating users and developers offer a user-centred approach.

3. Results

3.1 Understanding users

The 'user understanding' analysis resulted in a clustering of information into a number of headings – inputs (dealing with data sources and suppliers); outputs (customers and presentation) and characteristics of the potential users – their roles, goals, work, tools, expertise and skills. Some critical issues are unlikely to have emerged using a technology driven implementation model (see Figure 1). Among these were the variety in work undertaken from routine (for example, monthly crime reporting using "dashboards" - Few, 2006) to highly exploratory; the range of current tools employed and how loosely coupled they are; the emphasis the research officers placed on adding value (and how they managed to achieve that); their skill sets and expertise levels; the varied nature of their customers; and the spatial and temporal constraints on data availability.

3.2 Establishing user requirements

The strength of the Volere template is in its wide-ranging focus, exposing issues that would be unlikely to occur to a novice interviewer. It succeeded in eliciting a number of specific application requirements, including establishing a limit on the number of attribute datasets that would need to be considered in an analysis ("tens of datasets only"); the speed of screen refresh considered acceptable (indicating a low level programming language was not required); the preference for continuous zooming rather than selecting fixed areas from a menu; the desirability of, but not the necessity for, a background map layer to toggle on/off for orientation; the need for hands-on training (rather than documentation) to be able to use the application; and the importance of simplicity in the overall design and need to avoid unnecessary complexities.

However, the technique failed to provide an adequate bridge between the users and the developers to establish clearly the kind of tools, or interactions between tools, that might be required in the future application and this is where some modification is required to generate sufficient information to inform geovisualization design and designers. As it stands, the resolution of the Volere system is not fine enough for the complexities of geovisualization applications, or it cannot establish "undreamed of" requirements (Robertson, 2001). When prompted, the LCC research officers were able to indicate only two other applications that featured the kind of tools and interactions they believed might be useful - both websites. This is not unexpected given the complexity and specialized nature of geovisualization as a discipline and the techniques that it encompasses and may explain some of the difficulties reported by geovisualization researchers when testing their tools 'in the wild'.

In order to overcome this problem, a scenario developed to mediate between users and developers will additionally be used to mediate users to geovisualization experts - informing experts in geovisualization about the context of the research officers' work in LCC so that their expertise can be brought to bear on the interactive conceptual design of the application (see Figure 2). This technique will be evaluated using our reflective and adaptive technique.

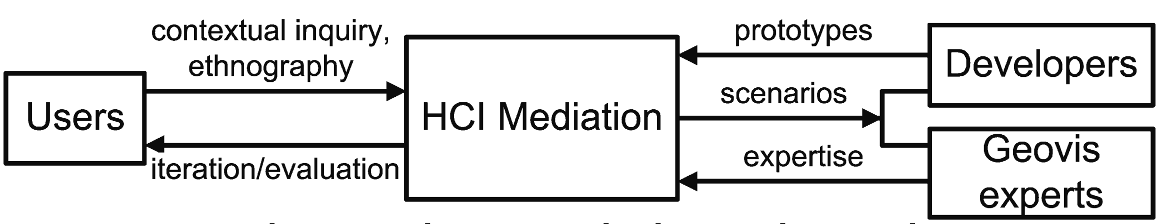

Figure 2: HCI techniques mediating users, developers and geovisualization experts.

4. Summary and Conclusions

In summary, we have had some success with HCI techniques, particularly those employed to understand users in detail, and these have informed the user-centred application creation process beneficially. Establishing requirements has been less satisfactory with the method employed unable to specify the complex tools and interactions that characterise geovisualization applications. However, another HCI technique, that of using ‘scenarios’, can be employed as a mediation bridge between users and geovisualization experts and has some promise. Our planned process of iterative prototype development with continual user involvement and reflection upon the quality of the results will enable us to evaluate both the geovisualization approach itself and the HCI techniques used to advance and evaluate it as we continue the user-centred application creation process.

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Biographies

David Lloyd is studying for a PhD on the use of human-centred techniques in geovisualization at City in collaboration with Leicestershire County Council. He completed his Masters in Geographic Information at City University London with distinction.

Jason Dykes is a Senior Lecturer in Geographic Information at City University with interests in geovisualization. A member of the ICA Commission on Visualization and Virtual Environments he has developed a number of software applications and is co-editor of “Exploring GeoVisualization” (Dykes, MacEachren and Kraak, 2005).

Robert Radburn is a Senior Research Officer at Leicestershire County Council working with a variety of partners and agencies to support evidence-based policy. He is a champion of the use of information visualization and geovisualisation techniques to inform service delivery within regional and local authorities.